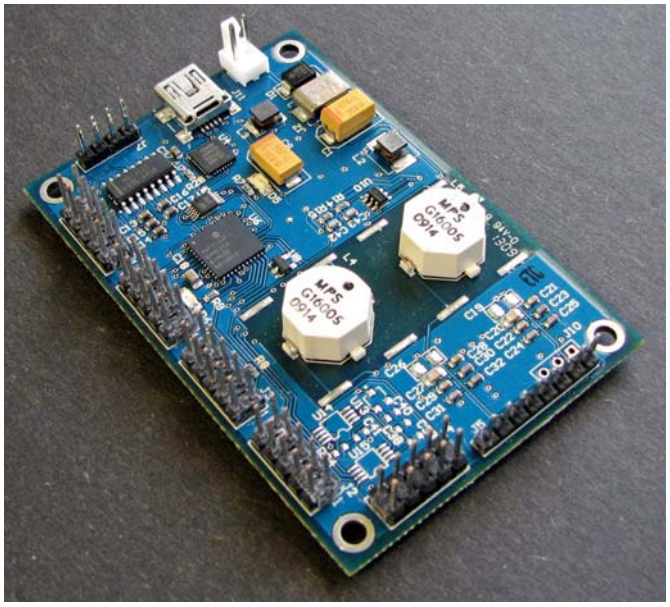
NEW SCALE TECHNOLOGIES

simple ceramic motors... inspiring smaller products



January 2014: Discontinued Product

MC-1100, Single Axis Controller and Squiggle OEM Motor System User's Manual

Covers:

SQUIGGLE™ Ultrasonic Motors
MC-1100 Single Axis Controller
MC-1100-100-K Single Axis Evaluation Kit
MC-1100HR Single Axis High Res. Controller
SQ-2301 Single Axis Handset

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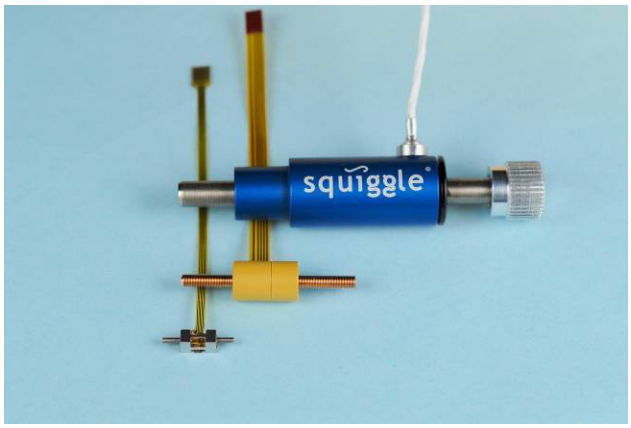
Table of Contents

1. Welcome

Thank you and congratulations on your purchase of the SQUIGGLE Motor Evaluation Kit. The kit includes:

- A SQUIGGLE™ motor.
- Drive electronics PCB with USB computer control or handset input.
- Power and USB cable
- 5 Volt power supply
- Manual handset (optional).

The SQL Series linear motors come in a range of sizes to meet the needs of markets ranging from small, portable consumer electronics to high precision instrumentation. The SQUIGGLE motor is a patented piezoelectric ultrasonic linear motor and is designed to withstand high shock and a broard temperature range and yet offer millimeters of stroke, sub-micrometer precision, high forces, and high efficientcies.



New Scale Technologies is constantly striving to improve the performance of the SQUIGGLE motor and satisfy the customer's needs for precise reliable motion. With this in mind, feel free to contact New Scale Technologies or visit our web site at www.newscaletech.com for the latest updates and exciting SQUIGGLE™ new

2. General Safety

Review the following safety precautions to prevent injury and avoid damage to this product. Use this product only as specified. Service procedures should only be performed by qualified personnel.

Follow these guidelines to insure safe and reliable operation of this product:

1. **Use Proper Power Cord.** Use only the power cord specified for this product and certified for the country of use.
2. **Connect and Disconnect Properly.** Do not connect or disconnect components while power is on. Unplug the power connection from the back of the unit before connecting or disconnecting any cables.
3. **Avoid Physical Shocks to the Motor.** The motor contains a piezoelectric actuator susceptible to excessive shock.
4. **Do Not Apply Side Loads the Motor Shaft.** Excessive side loads may damage the motor. Always apply loads parallel to the motor shaft.
5. **Do Not Retract Beyond Limit.** Do not allow the motor to overrun its travel limits when moving backwards. The threaded shaft may disengage from the internal threads. If this happens gently re-insert the screw until the threads are re-engaged and turning smoothly.
6. **Avoid Contact with Internal Electronic Circuitry.** High voltage is present inside the controller and motor when activated. Do not touch connections and components when power is on.
7. **Call Us If You Have a Problem or Question.** If your system is not operating within specifications or you have questions please contact us. Our service and support team is eager to help and will provide instructions for diagnosis and return to our factory for repair.

2.1 General Safety Summary

Do Not Operate in Wet/Damp Conditions.

Do Not Operate in an Explosive Atmosphere.

Do not Operating in the corona vacuum pressure range from 100 Torr to 10^{-3} Torr.

Keep Product Surfaces Clean and Dry.

2.2 Safety Terms and Symbols

This symbol indicates potentially dangerous voltages may be present when the motor is operating.

Only use an approved 5 Volt DC power supply or as provided by New Scale Technologies.

2.2.1 These terms may appear in this manual:

WARNING identifies conditions or practices that could result in damage, injury or loss of life.

CAUTION identifies conditions or practices that could result in damage to this product or other property.

DANGER indicates an injury hazard immediately accessible as you read the marking.

3. Contact New Scale Technologies, Inc.

Address	*New Scale Technologies, Inc.* *121 Victor Heights Parkway* *Victor NY, 14564* *USA*
Phone	*(585)-924-4450*
Fax	*(585)-924-4468*
Web	*www.newscaletech.com*
Sales	*sales@newscaletech.com*
Service	*nstservice@newscaletech.com*

4. Getting Started

This section describes:

1. Unpacking your product.
2. Performing a functional check of your product.
3. Installing the SQUIGGLE motor on a stage.
4. Installing the demonstration software.

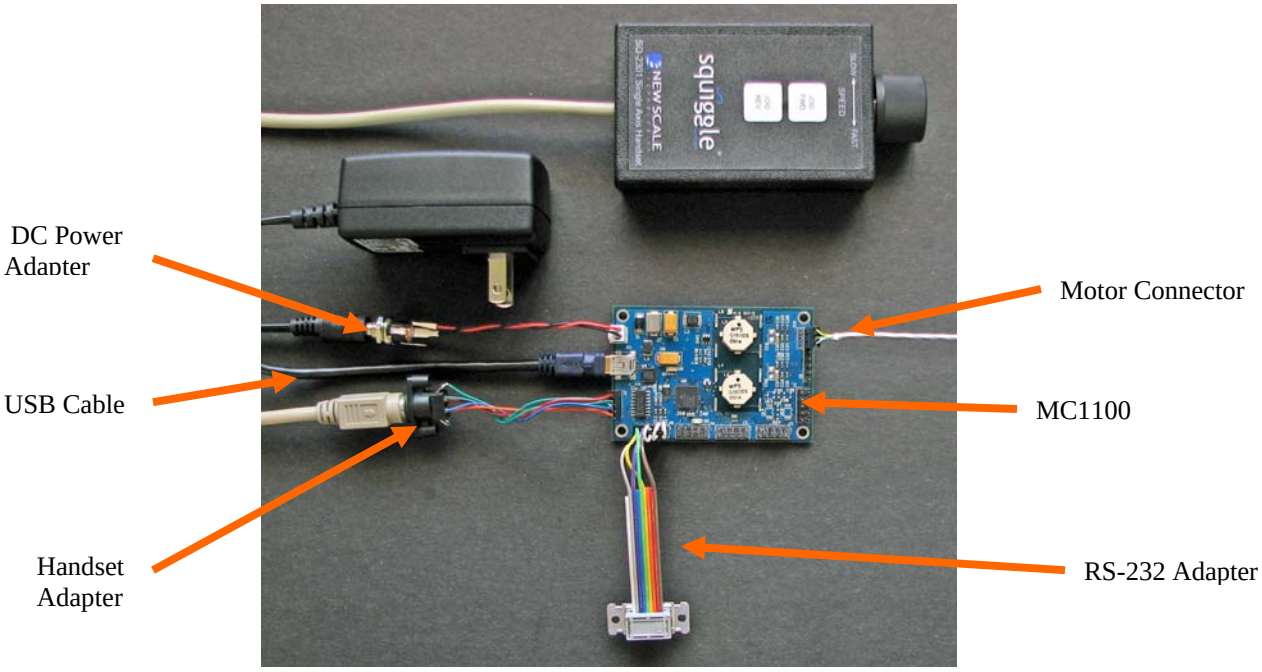
4.1 Unpacking Your Product

CAUTION: This product is a precision instrument and all components should always be handled with care. *Treat this product like you would a laptop computer or an optical microscope.*

The SQL EVALUATION KIT includes these items:

- SQUIGGLE Motor
- MC-1100 OEM Controller PCB
- SQ-2301 Single Axis Handset(optional)
- DC power supply with changeable power plug for country
- Software CD with NST Pathways software
- USB mini cable
- RS232 (Optional)

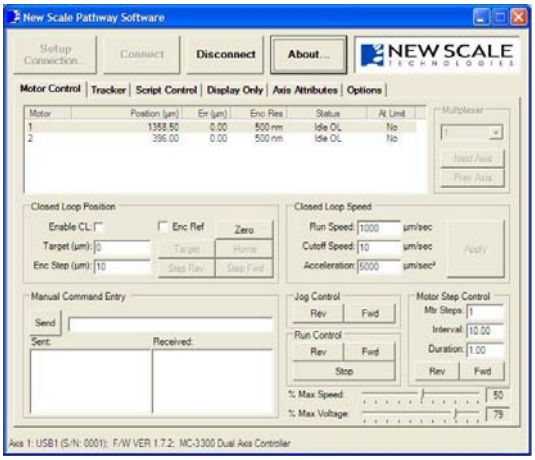
4.2 Setup, Connections and Manual Operation



Make these connections to the MC-1100 OEM Controller.

If using a handset, the SQUIGGLE motor may be manually operated by pushing and holding the JOG FWD or JOG REV buttons on the Handset and adjust speed by rotating the speed knob. Releasing the button will stop the motor. Note, the SQL series motors require a minimum 10-15 gram preload to move the shaft.

4.3 New Scale Pathway Software



The control software provided with the MC-1100 Motor Controller enables point-and-click control via a PC USB port. It also includes a scripting interface and an ActiveX command library.

Each MC-1100 Motor Controller can operate one SQUIGGLE motor, and you can manage multiple motor controllers simultaneously from a single control software window.

The control software and scripting interface allow you to easily evaluate open-loop and closed-loop performance of SQL Series SQUIGGLE motors.

4.4 Open-Loop or Closed-Loop Operation

We recommend closed-loop operation when repeatable step size, absolute position or precise velocity control is needed. The MC-1100 accepts input from remote position sensors or switches for closed-loop motion control.

With a digital (incremental) encoder as a position sensor, the resolution of the encoder determines closed-loop position resolution. With an analog position sensor, closed-loop position resolution is determined by the A/D converter, the resolution of the position sensor, and the resolution of the motor. For more information see the New Scale Application Note: *Creating Closed-Loop Positioning Systems Using SQUIGGLE Motors*.

In open-loop mode, you can calibrate a motor's average step size in response to a number of drive pulses. Open-loop resolution is listed on the motor data sheets.

MC-1100 with the TRACKER™

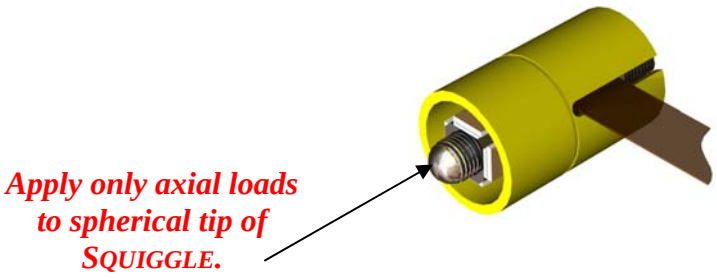
The MC-1100 can be used with the TRACKER™ Position Sensor. The TRACKER™ position sensor is a magnetic sensor array with integrated on-chip digital encoding. With 0.5 micron resolution and size as small as 3.9 x 2.5 mm, it is a robust, cost-effective alternative to miniature optical encoders for non-contact position sensing. See Tracker quick start guide for more information.

On-chip encoding provides direct digital output using standard I2C protocol, eliminating the need for external pulse counters. Efficient control system communications allows up to two TRACKER position sensors on a single I2C bus. (Custom position sensors with SPI and A quad B interface are also available; contact the factory.)

5. The SQL-3.4-10-xx SQUIGGLE Motor

The SQUIGGLE threaded shaft simultaneously rotates and translates inside the housing. The spherical tip of the shaft should press against a hard flat surface that is orthogonal to the shaft centerline as shown below. For detailed mounting instructions, see the Integration Guide for SQL-3.4-10 Motors.

CAUTION: The SQUIGGLE motor contains HIGH VOLTAGE. Be careful of exposed connections on adapter cable.



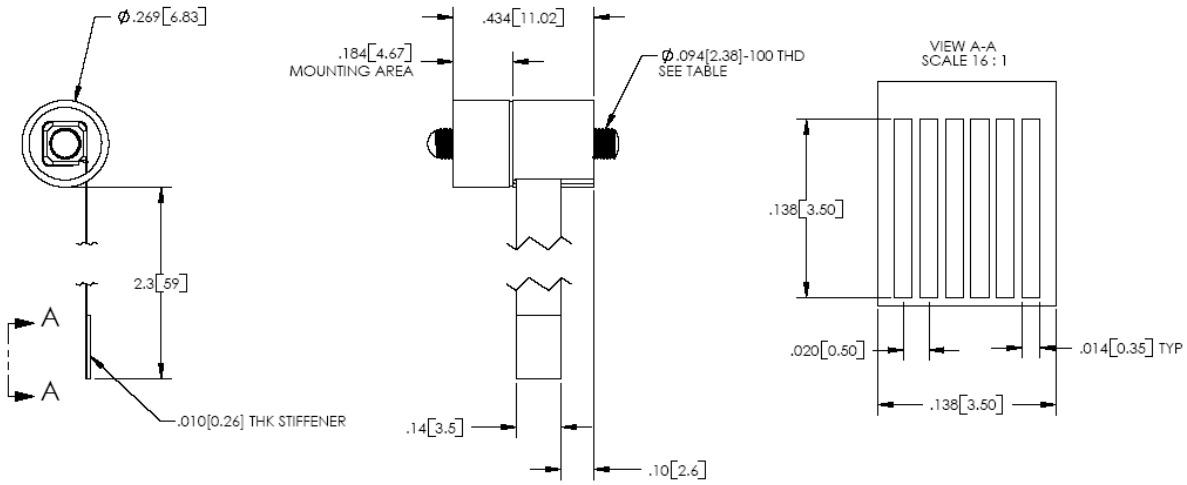
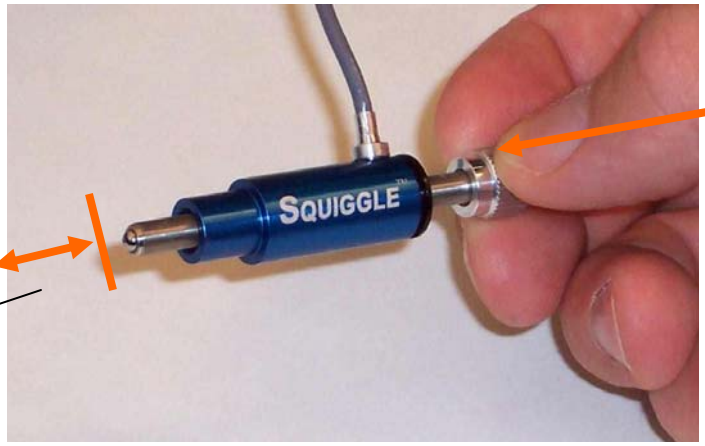


Figure 5-1 SQL 3.4-10 Dimensions and FPC Pin Out

6. The SQ-1XX SQUIGGLE Motor

The SQ-1XX SQUIGGLE motor is a complete micrometer replacement solution. It will adapt to most standard 0.375 inch threaded or non-threaded stage mounts.

The SQUIGGLE threaded shaft simultaneously rotates and translates inside the housing. The spherical tip of the shaft should press against a hard flat surface that is orthogonal to the shaft centerline as shown below. Use the knurled knob, opposite the spherical tip, to manually rotate the shaft.



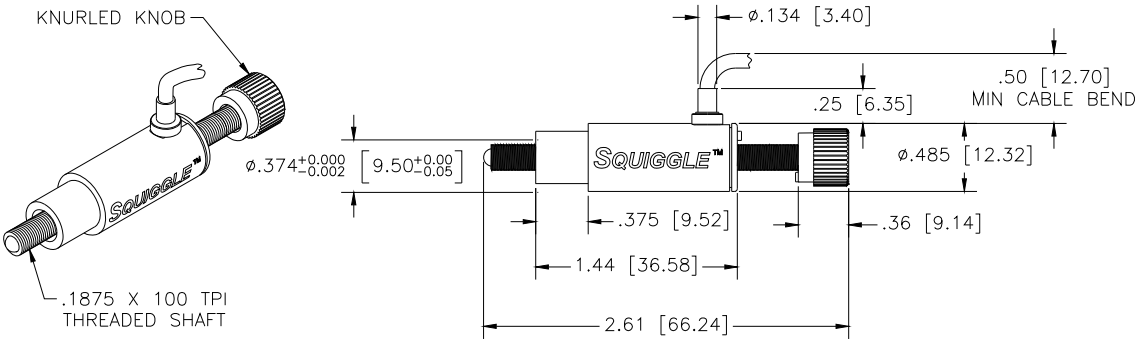
Use the knurled knob to manually rotate the screw.

Apply only axial loads to spherical tip of SQUIGGLE shaft using a hard flat surface.

CAUTION: DO NOT APPLY SIDE LOADS.

DANGER: Do not remove the housing or operate the motor with internal connections exposed. The SQUIGGLE motor contains HIGH VOLTAGE. Do not operate the motor if visually damaged.

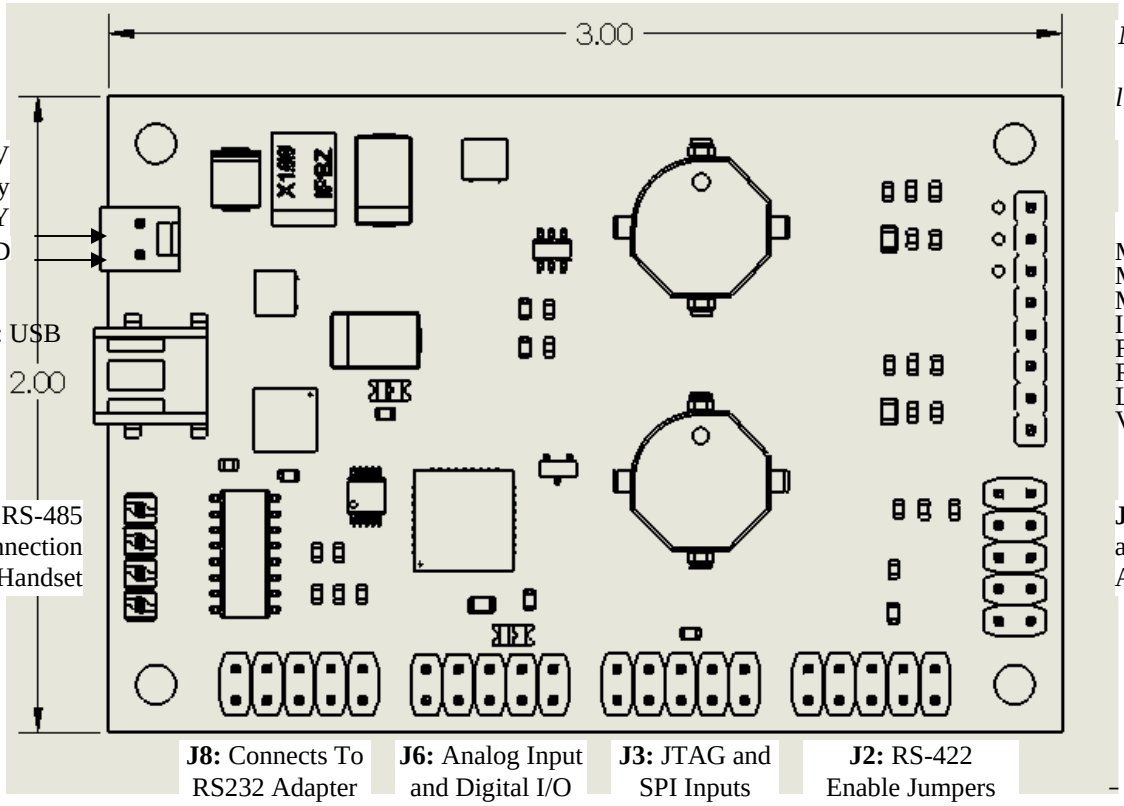
6.2Outline Drawing of SQ-115*



*Only shaft length change for other versions.

7. The MC-1100 Single Board OEM Controller

The MC-1100 Controller is capable of driving a single SQL-3.4 or SQ-1XX Series SQUIGGLE motor.



Note: *The Forward and Reverse Limit lines are active low.*

7.1 Operation

The basic principles of the MC-1100 controller operation consist of a digitally controlled resonant circuit. The resonant circuit is formed by components in the MC-1100 Controller and the SQUIGGLE motor. This electrical resonance is tuned to the mechanical resonance of the motor. Each motor type has operating parameters that the MC-1100 controller will read from its internal EEPROM. This information is set at the factory and is changeable by the user with specific instructions from New Scale Technologies.

The controller may generate a continuous drive signal (Amplitude Mode) or a series of drive signal bursts (Burst Mode) to the motor based on the EEPROM settings and the amplitude/duration determined by the Speed setting.

In Amplitude Mode, the % Max Speed setting referrers to the amplitude of the drive signal. The drive signal itself is continuous (at the motor drive frequency) while the motor is running.

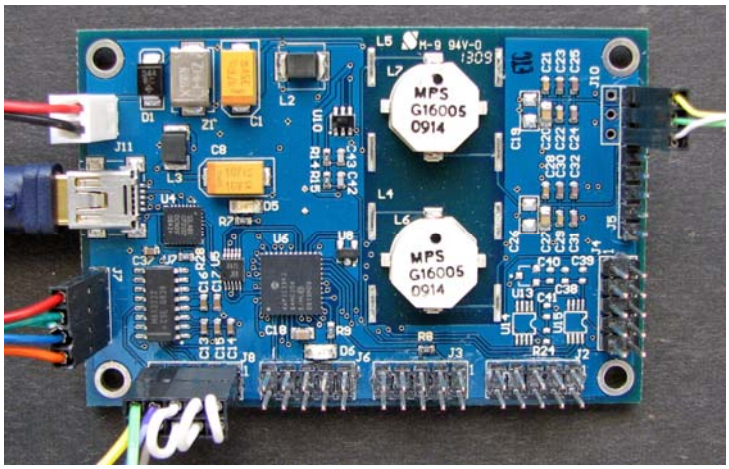
In Burst Mode, the % Max Speed setting referrers to duration that the drive signal is active within a 10 msec (i.e. 100Hz) period. The amplitude of the drive signal in this case is taken from a preset value in the MC-1100's EEPROM. The drive signal burst is repeated every 10 msec while the motor is running.

A combination mode is also available that allows the user to define a specific number of bursts to perform, the period and duration of each burst and the amplitude of the burst. This is referred to as the "Step Control" in the user interface of the demonstration program. Note, however, the actual distance moved with each burst (or timed step) is load dependent.

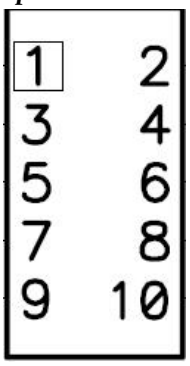
LED operation:

- Green LED: LED is ON, it indicates that the board is powered.
- Yellow LED: ON indicates USB is plugged in.
- Yellow LED: Blinking indicates that the attached motor is being driven.

7.2 Controller Connectors



Note the pin assignments of the 10-pin connectors:



Close-up View of Motor, Handset, RS232 and Power Connections

The following sections describe the pin functions of each connector.

7.2.1 OEM Board Power Connector (J1)

Pin	***Pin Name***	***Description***
1	Vin	Main supply input, 4.5 to 5.5 volts (max).
2	GND	Ground reference

7.2.2 RS-422 Encoder Enable Jumper Connector (J2)

See also the Encoder Input Connector (J4).

Pin	***Pin Name***	***Description***
1	Zero (JMP)	Jumper to pin 2 for RS422 operation
2	Zero (LVTTL)	Encoder Zero (Direct logic input)
3	PHA (JMP)	Jumper to pin 4 for RS422 operation
4	PHA (LVTTL)	Phase A (Direct logic input)
5	PHB (JMP)	Jumper to pin 6 for RS422 operation
6	PHB (LVTTL)	Phase B (Direct logic input)
7	RS422 (JMP)	Jumper to pin 6 to power RS422 receiver.
8	Vcc	3.3 Volts
9	Vin	5 Volt Vin
10	GND	Ground connection

7.2.3 Program and SPI Connector (J3)

Pin	***Pin Name***	***Description***
1	PDC/SDI	dsPIC data clock / SPI data in

2	Vcc	3.3 Volts
3	PGD/SDO	dsPIC data / SPI data out
4	NC	No connect
5	/MCLR	Processor reset and Vpp program voltage connect
6	GND	Ground connection
7	SDA	I^2C SDA line
8	ANALOG_CUR	Current sense feedback
9	SCL	I^2C SCL line
10	NC	No connect

7.2.4 RS-422 Encoder and Optional 16-bit ADC Input Connector (J4)

See also the Encoder Enable Jumper Connector (J2). If you have the 16-bit ADC option, you will need to configure the controller EEPROM to use that ADC rather than the processor's own internal 10-bit ADC. .

Pin	***Pin Name***	***Description***
1	ENCB+	Phase A positive encoder connect
2	ENCB-	Phase A negative encoder connect
3	ENCA+	Phase B positive encoder connect
4	ENCA-	Phase B negative encoder connect
5	ENCZ+	Index mark positive encoder connect
6	ENCZ-	Index mark negative encoder connect
7	Vcc	3.3 Volts
8	GND	Ground connection
9	VREF_ADC16	3V Reference Output for 16-bit ADC Option
10	ADC16BIT	0-3V Input for 16-bit ADC Option

7.2.5 Motor Connection (J5)

If the forward direction of motion is the opposite of what you would like, reverse the Phase1 and Phase2 connections.

Pin	*Pin Name*	*Description*
1	Vcc	3.3 Volts
2	GND	Ground connection (limit return line)
3	R_LIM	Reverse limit connect (active low)
4	F_LIM	Forward limit connect (active low)
5	INTLCK	Interlock (if used, normally no connect)
6	PHASE2	Motor Phase 2 connect
7	GND	Motor return connect
8	PHASE1	Motor Phase 1 connect

7.2.6 External Control Connector (J6)

Pin	*Pin Name*	*Description*
1	Vcc	3.3 Volts
2	GND	Ground connection
3	ADC0	Use for analog position sensor (if any)
4	SERVO	Use for analog servo input (if any)
5	NC	No connect
6	SERVO_RUN/STOP	Servo Run/Stop Input (Active Low)
7	SPARE3	Spare connection
8	SERVO_ENABLE	Servo Enable Input (Active Low)
9	SPARE2	Spare connection
10	NC	No connect

7.2.7 Handset Connector (J7)

Pin	*Pin Name*	*Description*
1	Vcc	3.3 Volts
2	GND	Ground connection
3	B	RS485 connection B
4	A	RS485 connection A

7.2.8 RS232 Connector (J8)

RS232 disabled if USB connected.

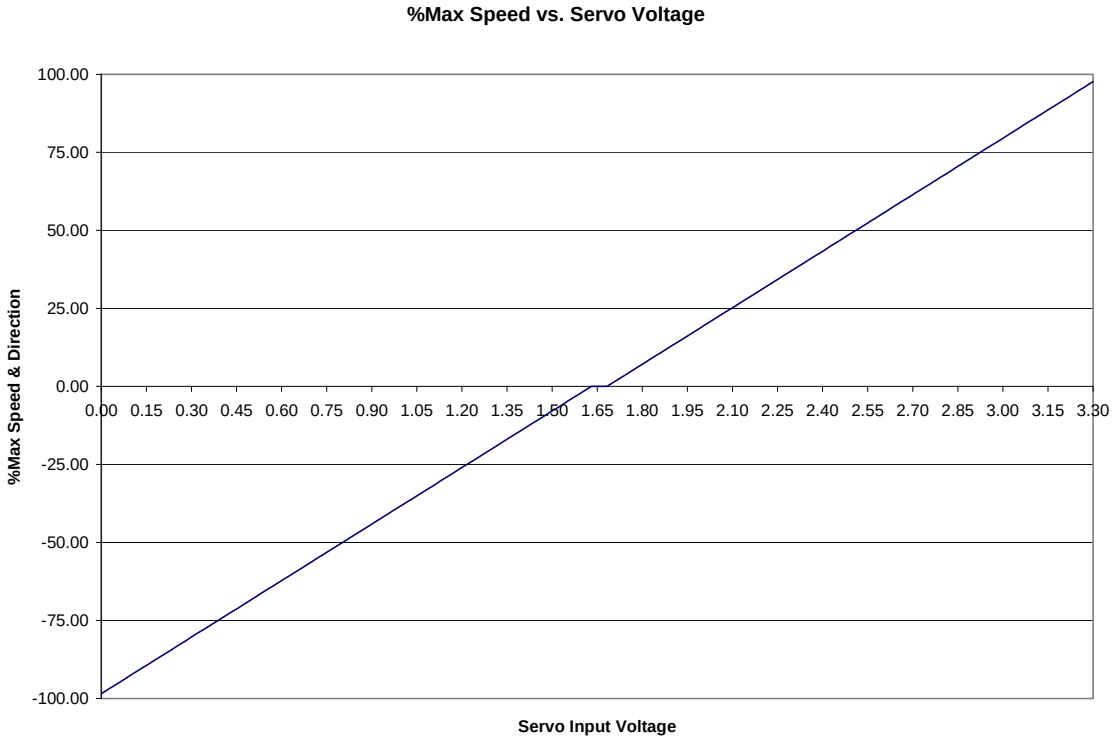
Pin	*Pin Name*	*Description*
1	RS232 (JMP)	Jumper to pin 2 to power RS232 receiver.
2	Vcc	3.3 Volts
3	TX (JMP)	Jumper to pin 4 for RS232 operation
4	TX (LVTTL)	Transmit (Direct logic output)
5	RX (JMP)	Jumper to pin 6 for RS232 operation
6	RX (LVTTL)	Receive (Direct logic input)
7	TX1	Transmit from SQPCB to external P
8	GND	Ground connection
9	RX1	Receive to the SQPCB from external PC
10	RS232 handshake	Hardwired low (High to RS232)

7.3 Analog Servo Control

The MC-1100 provides an analog servo input that may be used instead of the USB/RS-232/PC connection to control the speed and direction of the motor.

Section 7.2.6 specifies the pins that are necessary to implement servo control (see pins 4, 6 and 8). Note that these inputs are ignored once a connection is established from a PC via the USB or RS-232 port.

The following plot illustrates the relationship between the servo input voltage and the speed and direction of the motor. Note that both pins 8 (servo enable) and 6 (servo run/stop) must be low in order to move the motor.



At the center voltage (1.65V) covering a range of about 0.07 volts, is a dead band over which the motor drive will be turned off. While the motor is off, the dead band increases to about 0.12V to prevent on/off oscillations.

7.4 Controller Handset

The handset contains a small microprocessor that converts button activations and speed adjustments into ASCII commands and sends them over an RS-485 link to the MC-1100 controller.

SQ-2301 Handset

- By pressing and holding the "JOG FWD" button the shaft moves in the forward (screw out) direction. Motor will stop when released.
- By pressing and holding the "JOG REV" button the shaft moves in the reverse (screw in) direction. Motor will stop when released.
- Speed can be changed while moving by turning the knob at the top of the Handset. This is a 1-turn potentiometer that allows maximum to minimum speed adjustment.

CAUTION: When a button is pressed, the speed is set from the handset. If speed was set from another source it will be overridden by the handset.

8. Integration Guide

The MC1100 Squiggle controller is intended for space limited and OEM applications. It will depend on a user's system vulnerability whether or not problems can occur. When the MC1100 is integrated with other electronics, users should be aware of potential integration issues and pay attention to all aspects of how the MC1100 interacts with their system as a whole

The MC1100 driver board works on the principal of generating high voltage through the use of series resonant circuits. The amplitude of the resonant circuit voltage is controlled by a Microchip dsPIC microcontroller by varying the drive duty cycle, input voltage and resonant circuit components. The 2 resonant circuits provide the sine/cosine drive signals used to excite the mechanical resonance of the Squiggle motors elements. The resonant circuit itself is made up of resonant inductors, padding capacitance on the board and the motor capacitance. Squiggle motors require up to 200 VRMS to operate. The resonant circuit drive technique provides a tremendous power, complexity and cost savings over traditional linear drive systems.

The inductors on the MC1100 store energy on each cycle. It is also expected that a relatively large magnetic field will be generated around the inductor. For this reason, toroid inductors were chosen for the smallest field and potential to radiate.

Magnetic fields however do not carry over long distances as a radiated signal might. The signal strength will drop off rapidly as you move away from the magnetic source. Shielding the resonant inductors is not always practical as this will change the characteristics of the inductor and increase losses. If the magnetic field is suspected as a problem, simply moving the inductors even a small distance away from sensitive circuits can make a big difference.

Circuit losses and motor loading will damp the resonant signal that is replenished at the beginning of each cycle. The MC1100 will draw current based on the drive needed. At these low frequencies, bypass capacitance cannot support enough storage to completely smooth the input current draw. This is normal and expected behavior. As long as the power input has sufficient regulation and current capacity there should be no issues. Short low impedance power connections, a stable, properly sized power supply and low ground return resistance will ensure voltage levels remain within proper levels.

8.1 Other potential issues to be aware of:

- Pay particular attention to common grounding issues such as ground loops and long or too thin return traces.
- The power supply to the MC1100 should be at the proper voltage levels, well regulated and be able to provide not only the steady state current but also brief surge currents when necessary without losing regulation.
- Logic levels on the MC1100 are 3.3 Volt except where specified in section 7. Do not draw excessive power from the onboard 3.3 Volt supply as this may cause intermittent behavior or a failure. It can be used to power external sensors or other electronics when needed. See section 7 for details.
- The MC1100 will only accept a single 5 volt supply (4.5 to 5.5 Volt) power input. The internal motor drive supply is set at the factory and depends on the motor type.
- Unused functions on the controller board can be disabled to conserve power. Some connectors, such as the encoder connectors can be configured for various inputs based on individual needs.

9. Specifications Summary

9.1 SQ-1XX Motor

Size	
Housing Diameter	*0.485 inches, (Mounting diameter is 0.375 inches.)*
Housing Length	*1.44 Inches*
Shaft Diameter	*0.187 Inches with 100 Threads/Inch*
*Shaft Length**	*SQ-115; 2.54 Inches* *SQ-1XX; Consult New Scale Technologies for travel length options. Custom lengths possible.*
*Travel**	*SQ-115; More than 0.5 inches.*
Resolution	*Less than 100 nanometers*
Maximum Speed	*>2 mm/second with no load*
Minimum Speed	*Approximately 1 micrometer/second*
Stall Force	*5 Newtons minimum*
Drive Voltage	*~ 200 VAC*
Backlash	*None*
Off Power Hold	*Yes. (Threads are self locking.)*
*Optional Linear Stage***	*40 mm X 40 mm with 19 mm height.*

* Consult New Scale Technologies for travel length options. Custom lengths are available on request.
** New Scale Technologies can adapt a Squiggle motor to your stage requirements if needed.

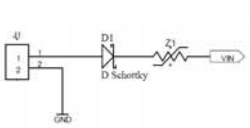
9.2 SQ-2001 Single Axis Handset

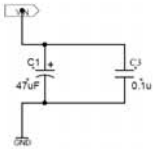
Size	*4.5 X 2.5 X 1.0 Inches (Length X Width X Height)*
Power	*.25 Watts max*
Temperature	*Storage: 0°C to 70°C, Operation: 0°C to 40°C*

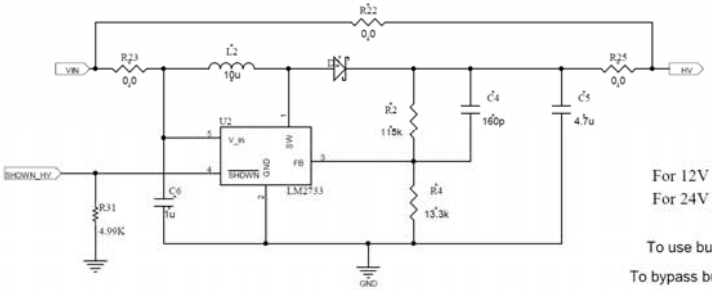
10. MC-1100 Board Schematics

The following pages are the MC-1100 Board (Rev2) Schematics

Rev.	Date	Description	Author
1	28 Apr 2008	Prototype	Cigna
2	11 Dec 2008	Fixed 1E6 mistakes	Cigna
3			
4			
5			



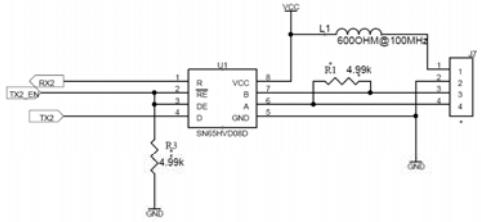


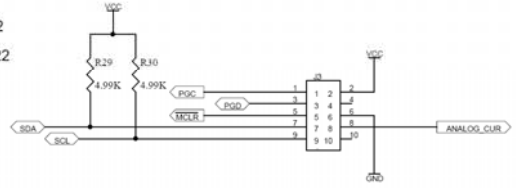


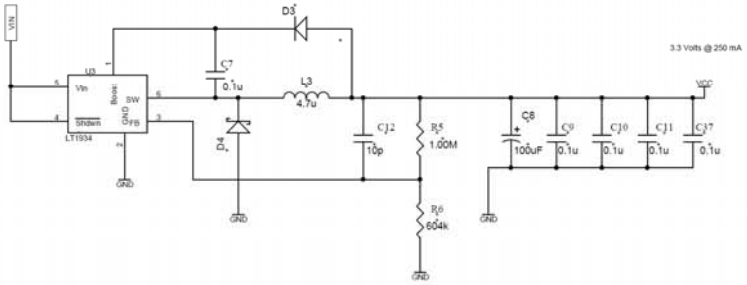
For 12V R4 = 13.3k
For 24V R4 = 6.2k

To use built in HV supply: populate R23, R25, remove R22

To bypass built in HV supply: remove R23, R25, populate R22







	New Scale Technologies Inc.	
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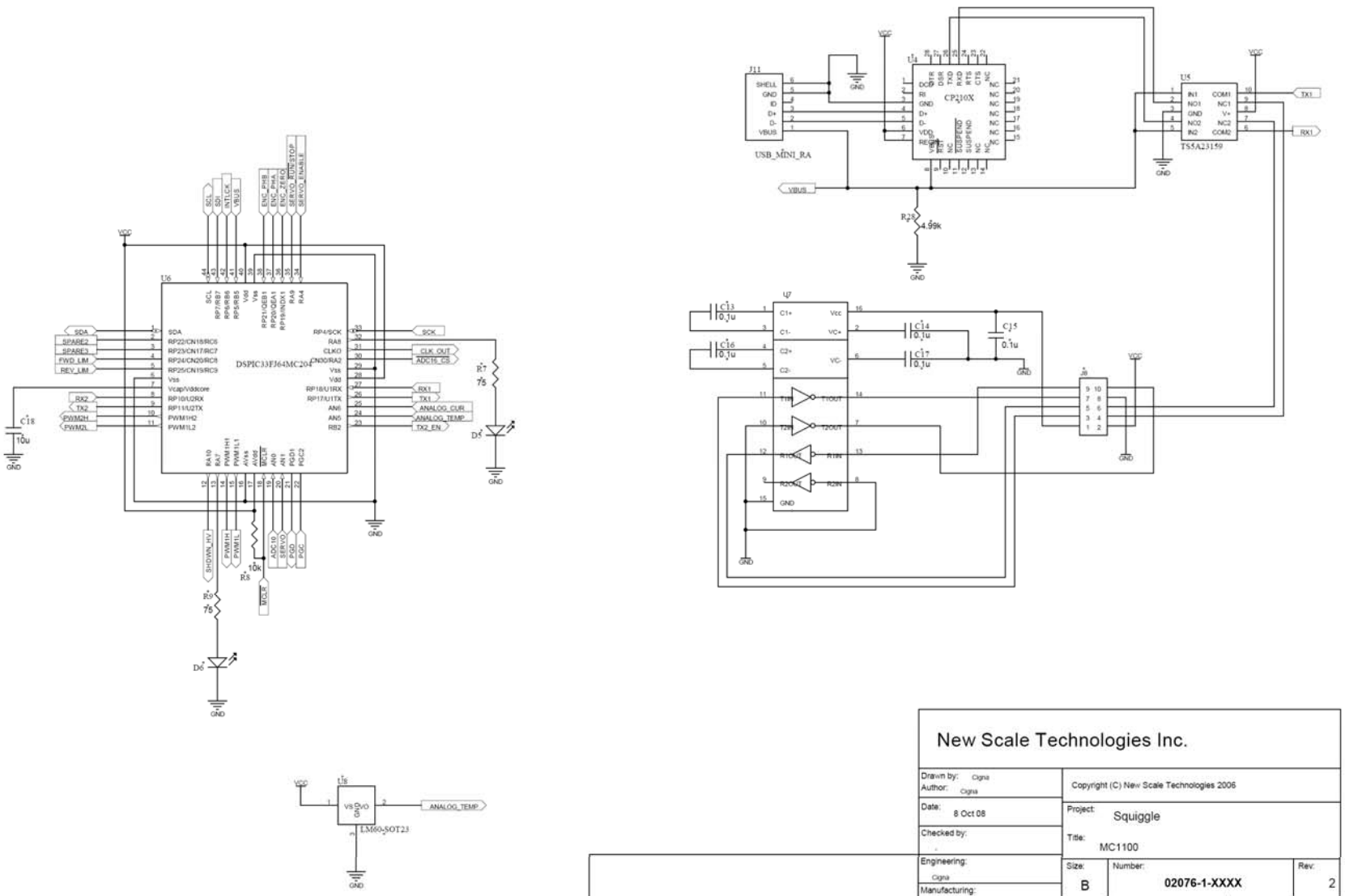
Manufacturing: -	Filename: 02076-1-SH1.SCHDOC	Sheet 1 of 4


New Scale Technologies Inc.
Drawn by: Cigna
Author: Cigna
Date: 8 Oct 08
Checked by:
Engineering: Cigna
Manufacturing:
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Project: Squiggle
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Sheet 2 of 4
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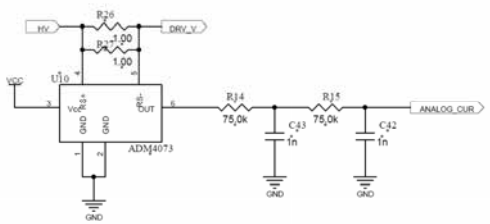
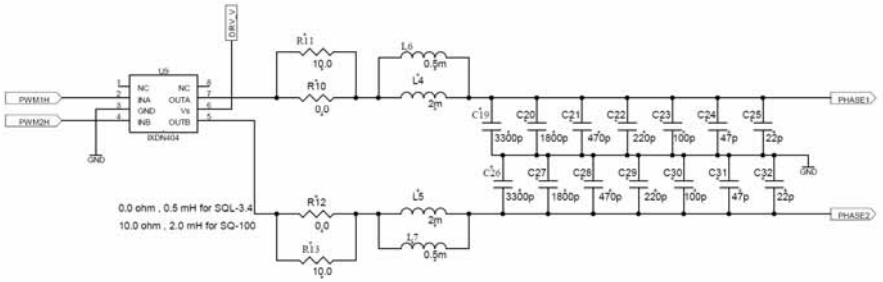
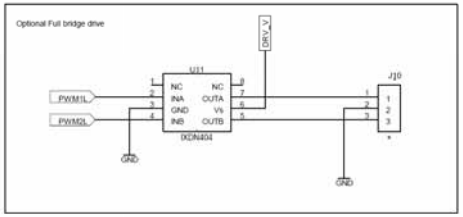
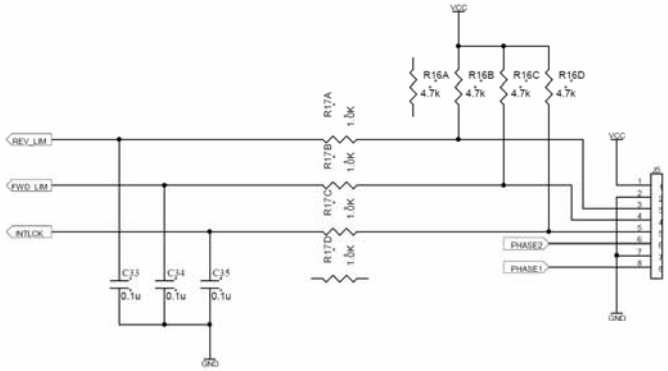
LM60-SOT23









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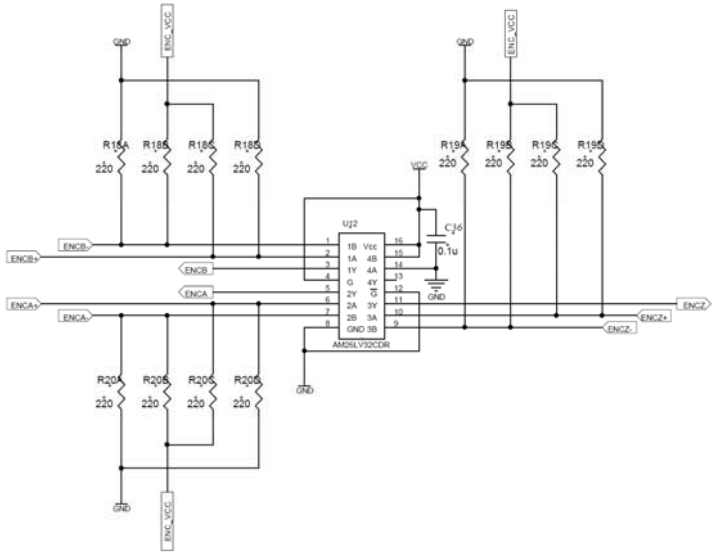
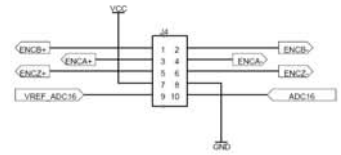
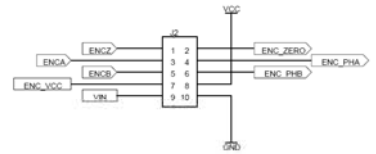
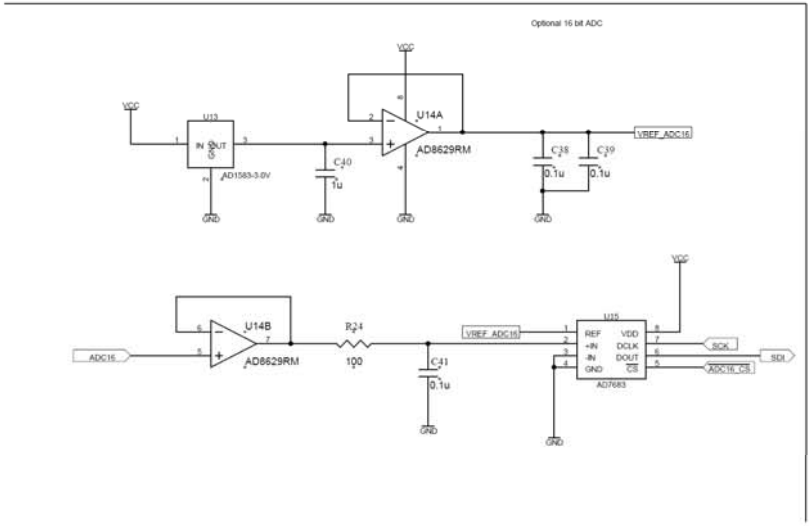
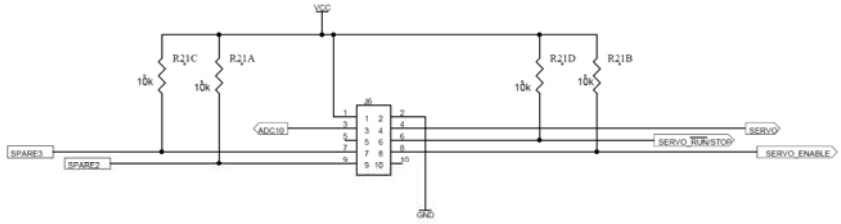
Engineering: Cigna	Size: B	Number: 02076-1-XXXX Rev: 2
Manufacturing: -	Filename: 02076-1-SH3.SCHDOC	Sheet 3 of 4











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Manufacturing: -	Filename: 02076-1-SH4.SCHDOC	Sheet 4 of 4

11. Warranty

New Scale Technologies, Inc. warrants that the products that it manufactures and sells will be free from defects in materials and workmanship for a period of one (1) year from the date of shipment. If a product proves defective within the respective period, New Scale Technologies will provide repair or replacement.

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